Seasonal Successions of Phytoplankton in Five Lake Basins in the Experimental Lakes Area, Northwestern Ontario, following Artificial Eutrophication. Data from 1980 to 1982

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SEASONAL SUCCESSIONS OF PHYTOPLANKTON IN FIVE LAKE BASINS IN THE EXPERIMENTAL LAKES AREA, NORTHWESTERN ONTARIO, FOLLOWING ARTIFICIAL EUTROPHICATION. DATA FROM 1980 TO 1982

by

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ABSTRACT

Findlay, D.L. 1983. Seasonal successions of phytoplankton in five lake basins in the Experimental Lakes Area, northwestern Ontario, following artificial eutrophication. Data from 1980 to 1982. Can. Manuscr. Rep. Fish. Aquat. Sci. 1710: iv + 30 p.

This report summarizes the changes which occurred in five lake basins during artificial enrichment with carbon, nitrate and phosphorus. Also discussed is the recovery of four of the basins. Data presented comes from studies of Lakes 227, 226 (north and south basins) and 302 (north and south basins). Included are 12 figures showing total biomass and percent composition and 12 tables listing common species found throughout this period.

Key words: plantonic algae; biomass; lakes; eutrophication; enrichment.

RESUME

Findlay, D.L. 1983. Seasonal successions of phytoplankton in five lake basins in the Experimental Lakes Area, northwestern Ontario, following artificial eutrophication. Date from 1980 to 1982. Can. Manuscr. Rep. Fish. Aquat. Sci. 1710: iv + 30 p.

Ce rapport résume les changements qui se sont produits dans cinq bassins de lac au cours de leur enrichissement artificiel en carbone, en nitrate et en phosphore. Le rapport porte également sur le rétablissement de quatre de ces bassins. Les données proviennent des études effectuées sur les lacs 227, 226 (bassins nord et sud) et 302 (bassins nord et sud). Le rapport comprend en outre douze illustrations des biomasses totales et de leur composition, en pourcentages, ainsi que douze tableaux où figurent les noms des espèces communes qu'on y a retrouvées pendant l'étude.

Mots-clés: algues planctoniques; biomasse; lacs; eutrophisation; enrichissement.

INTRODUCTION

This report summarizes the seasonal successions of phytoplankton communities in five lake basins in the Experimental Lakes Area (ELA) near Kenora, Ontario from 1980 to 1982. Only the basin of Lake 227 is continuing to be artificially eutrophied. Lake 226 north, 226 south, 302 north and 302 south are being monitored during their early recovery.

METHODS

Identification and counting techniques were the same as those described by Findlay (1978). For more detail and information on lake sizes and loading rates see Findlay (1980). The metalimnions and hypolimnions were sampled only if they were within the 1% light level.

RESULTS

LAKE 227

1980

Epilimnion (Fig. 1, Table 1): Lake 227, fertilized since 1969, continued to receive weekly additions of nitrogen and phosphorus, at a ratio of 5:1 by weight, throughout the 1980 season.

As in previous years the epilimnion was dominated in spring, early summer and fall by chlorophytes, mainly Scenedesmus spp., Chlamydomonas spp. and Oocystis sp. From mid July until mid August the standing crop was dominated by cyanophycean species Aphanizomenon gracile, Anabaena cylindrica and Oscillatoria Redekie. The only other prominant group to appear was in late August when Peridineae increased to 21% of the standing crop.

Biomass estimates ranged from 12 700 $mg \cdot m^{-3}$ in May to a low of 1 809 $mg \cdot m^{-3}$ in early August. There were two pulses which occurred, one in early spring and the second in late fall with biomass in mid summer slumping.

Metalimnion (Fig. 2, Table 2): The metalimnion in Lake 227 was sampled from early May until August. During this period it was dominated by Scenedesmus spp. and Oocystis sp., chlorophytes. Throughout the duration of the season cyanophycean species constituted 15 to 30% of the biomass with the same species which dominated the epilimnion. Biomass ranged from 3 900 to 17 350 $mg \cdot m^{-3}$, peaking in mid June.

1981

Epilimnion (Fig. 1, Table 1): Fertilization of Lake 227 continued as in previous years.

The epilimnetic standing crop consisted of 70 to 90% Chlorophyceae from April to mid July. Scenedesmus spp. were the dominant chlorophytes. By late July dominance shifted to cyanophytes (Anabaena cylindrica and Aphanizomenon gracile). Cyanophycean dominance lasted until early September when chlorophytes returned with Scenedesmus spp. being the major contributor. Throughout the season a small population of chrysophytes existed with a pulse of Peridineae occurring in mid July.

Biomass was relatively stable, 3 000 to 5 000 $mg \cdot m^{-3}$, with the exception of late May and early June when it increased to 15 550 $mg.m^{-3}$.

Metalimnion (Fig. 2, Table 2): In 1981 the metalimnion was sampled from May through August. Scenedesmus spp. dominated the plankton assemblage for the entire time.

Biomass ranged from 3 000 $mg \cdot m^{-3}$ in early May to 11 300 $mg \cdot m^{-3}$ in late August.

1982

Epilimnion (Fig. 1, Table 1): Epilimnetic additions of nitrogen and phosphorus continued for Lake 227 in 1982.

The early spring phytoplankton community was dominated by chrysophytes, mainly Dinobryon sertularia, shifting quickly to a dominance of chlorophytes (Scenedesmus spp.). By late June the annual cyanophycean bloom began with Anabaena sp. and Oscillatoria Redekie dominating the standing crop for the remainder of the season. A large pulse of cryptophytes appeared in October.

Biomass estimates for 1982 were the highest ever recorded for this area. Spring values ranged from 5 000 to 13 700 $mg \cdot m^{-3}$ while chrysophytes and chlorophytes dominated. Biomass increased significantly with the onset of the cyanophycean bloom, 56 150 $mg \cdot m^{-3}$ at the beginning and peaking at 113 750 $mg \cdot m^{-3}$. Ninety-nine percent of the live biomass was cyanophytes at this time.

Metalimnion (Fig. 2, Table 2): The metalimnion was sampled from May to July, after which the 1% light level did not exceed the depth of the epilimnion and therefore sampling ceased. Chlorophyceae dominated throughout May and June giving way to cyanophycean dominance. The chlorophyte and cyanophyte in this strata were the same as those found in the epilimnion. A small population of diatoms existed in May and early June but then diminished.

LAKE 226 NORTH

1980

Epilimnion (Fig. 3, Table 3): Fertilization of the north basin of Lake 226 with carbon, nitrogen and phosphorus continued as in previous years (Findlay 1981).

The early spring standing crop was dominated by chrysophycean species (Dinobryon spp. and Chrysochromulina spp.) remaining from the winter. Chrysophyte dominance lasted only a short time giving way to Osillatoria Redekie, a cyanophyte. In mid June Oscillatoria Redekie receded, while Anabaena cyclindrica appeared in large numbers. During this period, a large portion of the biomass was composed of several species of chlorophytes, which became dominant in

early July. Chlorophytes continued to dominate throughout July and August with Oocystis lacustris being the major species. Osillatoria Redekie and Anabaena continued to constitute a large portion of the standing crop. An increase in Chrysochromulina spp. early in September once again made Chrysophyceae the dominant group. They remained dominant for the remainder of the season. Throughout October a large population of cryptophytes also existed, constituting up to 40% of the assemblage.

Metalimnion (Fig. 4, Table 4): The standing crop in the metalimnion changed dominance three times during the season. Chrysophyceae (Uroglenaamericana, Chrysochromulina spp. and Dinobryon spp.) dominated throughout May and June with a large population of cryptophytes also present in early May after ice-out. Cyanophyceae, chiefly Oscillatoria Redekie and Anabaena cylindrica, dominated giving way to chlorophycean dominance in early August. Oocystis lacustris was the major chlorophyte representing 45% of the total biomass. Chlorphytes dominated for the remainder of the season.

Biomass estimates for the metalimnion ranged from 5 000 to 12 000 $mg \cdot m^{-3}$ with the peak occurring when chlorophytes became dominant in August.

1981

Epilimnion (Fig. 3, Table 3): This was the first year since 1973 that the north basin of Lake 226 did not receive artificial nutrients. The curtain separating the two basins was left in place although it was deteriorating, possibly allowing some mixing between basins.

The phytoplankton population was dominated for the entire 1981 season by chrysophytes (Dinobryon spp., Chrysococcus sp., Chrysochromulina spp., Uroglena sp. and several others) with dominance shifting between several major species. Populations of cryptophytes, chlorophytes and diatoms were also present. Cyanophyceae appeared in mid July and again in late August but did not constitute a significant portion of the biomass as it did in every year when fertilization occurred (Findlay 1978, 1981; Findlay and Kling 1975).

Biomass values ranged from 1 100 to 2 900 $mg \cdot m^{-3}$ for the season. This is lower than in previous years.

Metalimnion (Fig. 4, Table 4): In 1981 species composition in the metalimnion was similar to that in the epilimnion. Chrysophyte dominance with smaller populations of chlorophytes, diatoms and cryptophytes were present throughout the sampling period.

Biomass estimates were high in late spring and early summer (6 000 $mg \cdot m^{-3}$), decreasing for the remainder of the season. The average biomass was 1 700 $mg \cdot m^{-3}$.

1982

Epilimnion (Fig. 3, Table 3): The standing crop was dominated by chrysophytes and diatoms. Chrysophyceae (Uroglena americana and Dinobryon spp) dominated in spring and late fall with diatoms (Rhizosolenia eriensis, Synedra acus) dominating in late June and July. Small populations of Cyanophyceae, Cryptophyceae, Chlorophyceae and Peridineae existed through the season.

Biomass was very stable through the season averaging 2 300 $mg \cdot m^{-3}$. There was a late season peak in late October (5 030 $mg \cdot m^{-3}$).

Metalimnion (Fig. 4, Table 4): Species composition was similar to that seen in the epilimnion. Cryptophyceae and Chrysophyceae were dominant in early May, after which Cryptophyceae were replaced by diatoms. Chrysophyceae were dominant through June but Bacillariophyceae increased to constitute the majority of the biomass later in June. The same species dominated both the epilimnion and the metalimnion.

Biomass averaged 4 000 $mg \cdot m^{-3}$ with very little fluctuation from one sampling date to another.

LAKE 226 SOUTH

1980

Epilimnion (Fig. 5, Table 5): The south basin continued to receive carbon and nitrogen as it has since 1973.

Species composition in early May after ice-out was composed of 65% Chrysophyceae, 15% Cryptophyceae and 10% Chlorophyceae. Chrysophytes dominated throughout May and early June (Uroglena americana, Dinobyron spp. and several small flagellated species) but decreased as diatoms and chlorophytes increased. By mid July chlorophytes were dominant with large populations of chrysophytes and cyanophytes present. Cyanophyceae (Oscillatoria Redekie, Anabaena cylindrica) became dominant in mid September and remained dominant until ice-cover.

Biomass fluctuated from 2 000 to 4 500 $mg \cdot m^{-3}$ averaging 3 110 $mg \cdot m^{-3}$ over the season.

Metalimnion (Fig. 6, Table 6): In 1980 the metalimnetic standing crop shifted dominance three times. In early spring chrysophytes constituted 75% of the biomass, with major species being Uroglena americana, Chrysochromulina spp. and Dinobryon spp. By mid June, chrysophytes declined and a large pulse of diatoms (Cyclotella glomerata, Rhizosolenia eriensis) increased to co-dominance. In early July diatoms subsided leaving chrysophytes dominant (60%) with major species being Synura sphagnicola and Chrysochromulina spp. Dominance shifted again in late August to Oscillatoria Redekie. Chrysophyceae remained prominent.

Biomass increased throughout May and June peaking in July (6 500 $mg \cdot m^{-3}$) then declining through the remainder of the sampling season.

1981

Epilimnion (Fig. 5, Table 5): The epilimnetic assemblage was dominated by several species of chrysophytes for the entire season. In

tate June and early July a pulse in the chlorophycean species Scenedesmus brevispina occurred, but diminished shortly after. The chlorophytes were then replaced by Peridineae (Gymnodinium sp.) which remained numerous for the remainder of the season. Cryptophytes, diatoms and cyanophytes where also detectable throughout the season.

Biomass estimates were noticeably lower than those in previous years, ranging from 800 in April to 2 100 $mg \cdot m^{-3}$ in late September.

Metalimnion (Fig. 6, Table 6): The metalimnion species composition was similar to that of the epilimnion. Chrysophyceae dominated for the entire season except for a short period in early July when Amphidinium sp., a dinoflagellate, was co-dominant with the chrysophytes. Prominent and stable populations of chlorophytes, diatoms and cryptophytes existed during the season.

Biomass estimates did not decline as noticeably from years of fertilization as that in the epilimnion. It fluctuated from 1 500 to 4 500 $mg \cdot m^{-3}$, averaging 2 600 $mg \cdot m^{-3}$.

1982

Epilimnion (Fig. 5, Table 5): Species composition was more uniform throughout the season than in earlier years. Chrysophyceae dominated, with a large population of Bacillariophyceae present (Rhizosolenia eriensis) during the ice free season. Also present were populations of Cyanophyceae, Chlorophyceae, Cryptophyceae and Peridineae.

Biomass values remained lower than those recorded in years of enrichment averaging 2 400 $mg \cdot m^{-3}$ over the six month period.

Metalimnion (Fig. 6, Table 6): The plankton assemblage in the metalimnion was almost identical to that recorded for the epilimnion. Chrysophyte dominance, with a large population of diatoms (Rhizosolenia eriensis, Cyclotella glomerata) were present. In addition, subpopulations of Cyanophyceae, Chlorophyceae, Cryptophyceae and Peridineae occurred.

Biomass estimates were high compared to those recorded in 1981, ranging from 1 600 to 3 500 $mg \cdot m^{-3}$.

LAKE 302 NORTH

1980

Epilimnion (Fig. 7, Table 7): From 1973 to 1976 and in 1978 the north basin of Lake 302 received carbon, nitrogen and phosphorus pumped below the thermocline (8 m). In 1980, sampling resumed to determine whether the lake's recovery was complete enough to begin a new experiment (Schindler et al. 1980). Sampling did not begin until June and then occurred monthly.

The standing crop was consistently dominated by chrysophycean species Uroglena americana, Dinobryon spp., Chrysochromulina spp. and numerous small flagellated chrysophytes. In August the peridinean species Gymnodinium sp. and Ceratium hirundinella increased, becoming co-dominant but then declined rapidly. Populations of cyanophytes, chlorophytes, diatoms and cryptophytes were also evident.

Biomass remained low, averaging only 1 400 $mg \cdot m^{-3}$, comparable to prefertilization estimates.

Metalimnion (Fig. 8, Table 8): As in the epilimnion, the metalimnion was dominated entirely by chrysophycean species. Present throughout the season was a large chlorophycean population composed of several species. Cryptophycean and peridinean populations were both conspicuous from June when they represented 5-10%, increasing to August when each constituted 24% of the community biomass.

Biomass ranged from 750 to 1 900 $mg \cdot m^{-3}$ which is similar to estimates prior to enrichment.

Hypolimnion (Fig. 9, Table 9): The hypolimnion was only sampled twice, both times in June. It was dominated by Dinobryon bavaricum and Uroglena americana. In early June a large population of cryptophytes was present but they diminished by mid June.

Biomass decreased from 3 500 to 1 600 $mg \cdot m^{-3}$ over the fourteen day period.

1981

Epilimnion (Fig. 7, Table 7): With the exception of early April, right after ice-out, when chlorophycean species Dictyosphaerium simplex was the most abundant species Chrysophyceae dominated (Chrysococcus sp., Dinobryon spp., Chrysochromulina spp. and Uroglena americana). Populations of cyanophytes, diatoms and cryptophytes appeared consistently through the season. A pulse of Peridineae was recorded in late July early August when Ceratium hirundinella increased.

Biomass increased to 5 300 $mg \cdot m^{-3}$ in late April then declined through May to remain stable between 1 250 to 2 000 $mg \cdot m^{-3}$.

Metalimnion (Fig. 8, Table 8): Species composition was erratic in 1981, with dominance shifting between several groups and species. Chrysophytes dominated in early spring, in August and in September with the species dominating as in the epilimnion. Chlorophytes dominated in early summer with Arthrodesmus incus becoming very abundant. They were replaced by Ceratium hirundinella in late July. By early August Ceratium hirundinella had decreased to an insignificant portion of the assemblage but increased again in mid August. Populations of Cyanophyceae, Bacillariophyceae and Cryptophyceae were also observed but did not contribute largely to the overall biomass.

Biomass peaked twice, once in the spring at 4 100 $mg \cdot m^{-3}$ after which it declined to 1 900 $mg \cdot m^{-3}$ through the summer, then increased to 2 900 $mg \cdot m^{-3}$ in early September.

Hypolimnion (Fig. 9, Table 9): The hypolimnion was sampled in May and June. Chrysophytes (Dinobryon spp., Mallomonas sp. and Uroglena

americana) dominated the community with population of chlorophytes, cryptophytes and dinoflagellates also contributing.

Biomass ranged from 2 100 to 3 200 $mg \cdot m^{-3}$.

LAKE 302 SOUTH

1980

Epilimnion (Fig. 10, Table 10): Throughout the season, the phytoplankton community was dominated by chrysophytes (Dinobryon spp., Chrysochromulina spp., Uroglena americana and several small flagellated forms). Cyanophyceae and Peridineae were most abundant in late July. Also conspicuous were small populations of chlorophytes, diatoms and cryptophytes.

Biomass was low through the summer ranging from 750 to 1 100 $mg \cdot m^{-3}$ but had doubled by late October.

Metalimnion (Fig. 11, Table 11): Species composition in this stratum was very similar to that in the epilimnion. Chrysophytes dominated with large pulses of chlorophytes in late July and dinoflagellates in late August.

Biomass estimates varied from 800 to 4 200 $mg \cdot m^{-3}$.

Hypolimnion (Fig. 12, Table 12): The hypolimnion was sampled twice; both times were in June. The standing crop was dominated by Chrysophyceae, (Mallamonas spp., Dinobryon spp.) with Cryptophyceae and Chlorophyceae populations contributing to the community.

Biomass estimates decreased from 4 650 $mg \cdot m^{-3}$ in early June to 3 200 $mg \cdot m^{-3}$ two weeks later.

1981

Epilimnion (Fig. 10, Table 10): Sampling began directly after ice-out in 1981. As in the previous season chrysophytes dominated for the entire time with many species contributing. Diatoms and peridinean species both increased in abundance in July, with the latter diminishing through the rest of the summer and while Synedra acus, a diatom, continued to form a consistent portion of the biomass for the remainder of the season. In addition to these groups, cyanophytes, chlorophytes and cryptophytes were also detectable.

Biomass estimates were high in early spring (4 300 $mg \cdot m^{-3}$) but declined throughout May and averaged 1 650 $mg \cdot m^{-3}$ for the remainder of the season. The summer values are comparable to those recorded in prior years.

Metalimnion (Fig. 11, Table 11): The standing crop of phytoplankton in the metalimnion was dominated again by chrysophytes. Species such as Chrysochromulina spp., Chrysococcus sp., Mallomonas sp., Synura sphagnicola, Uroglena americana and Dinobryon spp. were among the more common organisms. As in the previous years, Chlorophyceae were also very abundant representing up to 35% of the community with Arthrodesmus incus being the major contributor. Bacillariophytes, Cryptophytes and Peridineae were conspicuous through the season.

Biomass estimates ranged from 1 500 to 4 100 $mg \cdot m^{-3}$ with the largest values occurring in early spring and late summer.

Hypolimnion (Fig. 12, Table 12): As in the metalimnion, chrysophytes dominated the hypolimnion in spring with Dinobryon spp., Chrysococcus sp. Uroglena americana and Mallomonas sp. By mid June chlorophytes became dominant with Arthrodesmus incus. Chrysophyceae continued to represent 35% of the total assemblage at this time. Cyanophytes and diatoms were present but did not make a large contribution.

Biomass estimates were erratic, ranging from 2 800 to 7 300 $mg \cdot m^{-3}$ in a period of six weeks.

DISCUSSION

Lake 227 was the only lake continuing to be fertilized during 1980-1982. Throughout the period of fertilization when the N:P ratio was 5:1 by weight the standing crop was dominated by Chlorophyceae in spring (usually desmid species) giving way to cyanophyceae blooms in mid July (Oscillatoria sp. and Anabaena sp.). Since 1975 the concentration of the cyanophycean blooms has intensified (Fig. 1). This trend is also noticeable in the biomass estimates which have increased five times from 1981 to 1982. Biomass estimates in 1982 were far higher than any previously recorded in the lake. These increases coincide with an increase in total phosphorus in the epilimnion (Fig. 13). There was not a noticeable difference in the amount of light available.

So it appears that phosphorus is the major nutrient stimulating the excelled growth. The additions of phosphorous have not changed since 1975, and should have reached a steady state by 1980, suggesting that the increases may be caused by higher phosphorus returns from sediment (Schindler et al. in prep.).

The trend of higher biomass and large portions of Cyanophyceae is also evident in the metalimnion.

RECOVERY OF LAKES 226 AND 302

Fertilization in Lake 302 North ceased in 1978 and in 1981, fertilization ceased in Lake 226 north and south basins.

LAKE 226 NORTH

During 1980 when fertilization was continuing the standing crop was dominated by Chrysophyceae in spring giving way to summer and fall populations of chlorophytes and cyanophytes

(Fig. 3). Biomass estimates were 8 to 10 times higher than prefertilized values and for unfertilized lakes in the area.

In 1981, when enrichment ceased an immediate decrease in biomass was evident with values remaining comparable to pre-experimental estimates (Findlay and Kling 1975).

Species composition shifted to a community similar to that of prefertilization with chrysophycean species dominating many of those which existed before eutrophication began.

Low biomass estimates were also recorded throughout 1982 except in late fall. This could be due to phosphorus trapped in the hypolimnion being mixed with the epilimnion at fall overturn. Species composition in 1982 was similar to that in 1981 with chrysophytes dominating and a large portion of diatoms present. Chlorophytes and cyanophytes did not dominate at all during the season.

LAKE 226 SOUTH

The south basin of Lake 226 reacted similarly to the north basin although biomass and species composition was not greatly altered during the term of the experiment (Fig. 5).

During 1980 when carbon and nitrogen additions were continuing, the phytoplankton community shifted dominance several times going from a dominance of chrysophytes in spring to chlorophytes in summer and cyanophytes in the fall. But in 1981 and 1982 the assemblage was dominated solely by chrysophytes. Populations of chlorophytes and cyanophytes were present but in a reduced number.

Biomass declined in 1981 from that recorded in 1980, but then increased slightly in 1982.

LAKE 302 NORTH

Species composition was not greatly affected by the addition of carbon, nitrogen and phosphorus because it was injected below the thermocline and was not accessible to the epilimnetic phytoplankton except at spring and fall turnover. Therefore, there was not a dramatic shift in the assemblage when addition ceased. Chrysophytes dominated the entire seasons of 1980 and 1981.

Biomass was comparable to the south basin (Fig. 10) and other control lakes in our area. Higher values were recorded in the spring and fall of 1980 and again in the spring of 1981. This can be attributed to the remaining hypolimnetic phosphorus being mixed with the epilimnion during turnover.

In lakes which have only been fertilized for a few years, recovery from eutrophication is a rapid process as demonstrated by Lake 226 North (Fig. 3) which received additions of carbon, nitrogen and phosphorus for eight years and Lake 302 North which received the same elements for five years.

ACKNOWLEDGMENTS

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REFERENCES

FINDLAY, D.L. 1981. Seasonal successions of phytoplankton in seven lake basins in the Experimental Lakes Area, northwestern Ontario, following artificial eutrophication. Data from 1977 to 1979. Can. Manuscr. Rep. Fish. Aquat. Sci. 1627: iv + 40 p.

FINDLAY, D.L. 1978. Seasonal successions of phytoplankton in seven lake basins of phytoplankton in the Experimental Lakes Area, northwestern Ontario, following artificial eutrophication. Data from 1974-76. Can. Fish. Mar. Serv. Manuscr. Rep. 1466: iv + 41 p.

FINDLAY, D.L., and H.J. KLING. 1975. Seasonal successions of phytoplankton in seven lake basins in the Experimental Lakes Area, Northwestern Ontario, following artificial eutrophication. Can. Fish. Mar. Serv. Tech. Rep. 513: iii + 53 p.

FINDLAY, D.L., and G. SAESURA. 1980. Effects on phytoplankton biomass, succession and composition in Lake 223 as a result of lowering pH levels from 7.0 to 5.6. Data from 1974 to 1979. Can. Manuscr. Rep. Fish. Aquat. Sci. 1585: iv + 16 p.

SCHINDLER, D.W., T. RUSZCZYNSKI, and E.J. FEE. 1980. Hypolimnion injection of nutrient effluents as a method for reducing eutrophication. Can. J. Fish. Aquat. Sci. 37: 320-327.

Table 1. Lake 227

Common Species (5%)

Strata/Year	Date	Cyanophyceae	Chlorophyceae	Chrysophyceae	Cryptophyceae	Peridineae
Epi 1980		Oscillatoria Redekei Van Goor	Scenedesmus brevispina Chodat Dictyosphaerium simplex Skuja Oocystis submarina va. lacustris Skuja Scenedesmus quadricauda Breb. Chlamydomonas spp.		Cryptomonas erosa Ehren.	Peridinium inconspicuum Lemm.
	Jun-Jul	Anabaena LeVanderi Lemm.				
	Jun-Aug		Spondylosium planum W. & G.S. West Oocystis lacustris Chodat	Salpingoeca frequentissima Lemm.		
		Anabaena cylindrica Lemm.				
	Jul-Aug	Aphanizomenon gracile Lemm.				
	Jul-Oct					Gymnodinium sp.
Epi 1981	Apr-Oct		Scenedesmus denticulatus Lager. Chlamydomona sp.	Dinobryon cylindricum Imhof		Gymnodinium sp.
	May-Oct		Scenedesmus quadricauda Breb. Oocystis lacustris Chodat			
		Oscillatoria Redekei Van Goor	Scenedesmus brevispina Chodat			
	Jun-Jul		Dictyosphaerium simplex Skuja	Chrysochromulina parva Lackey		
		Aphanizomenon gracile Lemm.	Spondylosium planum W.& G.S. West Carterier sp.	Salpingoeca frequentissima Lemm.		Peridinium inconspicuum Lemm.
	Jul-Oct	Anabaena planctonica Brunn. Anabaena LeVanderi Lemm. Aphanizomenon gracile Lemm.				
	Aug-Oct		Spondylosium planum W. & G.S. West	Salpingoeca frequentissima Lemm.		
Epi 1982	May-Jul	Oscillatoria Redekei Van Goor	Scenedesmus denticulatus Lager. S. brevispina Chodat	Dinobryon sertularia Ehren.		Gymnodinium sp.
				Chrysochromulina parva Lackey	Cryptomonas erosa Ehren.	Peridinium aciculiferum Lemm.
	Jun-Oct	Anabaena planctonica Brunn. Oscillatoria Redekei Van Goor	S. denticulatus Lager. S. brevispina Chodat		Cryptomonas rostratiformis Skuja C. erosa Ehren. C. ovata Ehren.	
			Chlamydomonas spp.	Salpingoeca frequentissima Lemm.		Gymnodinium sp.
	Oct	Anabaena sp.		Dinobryon sertularia Ehren.		

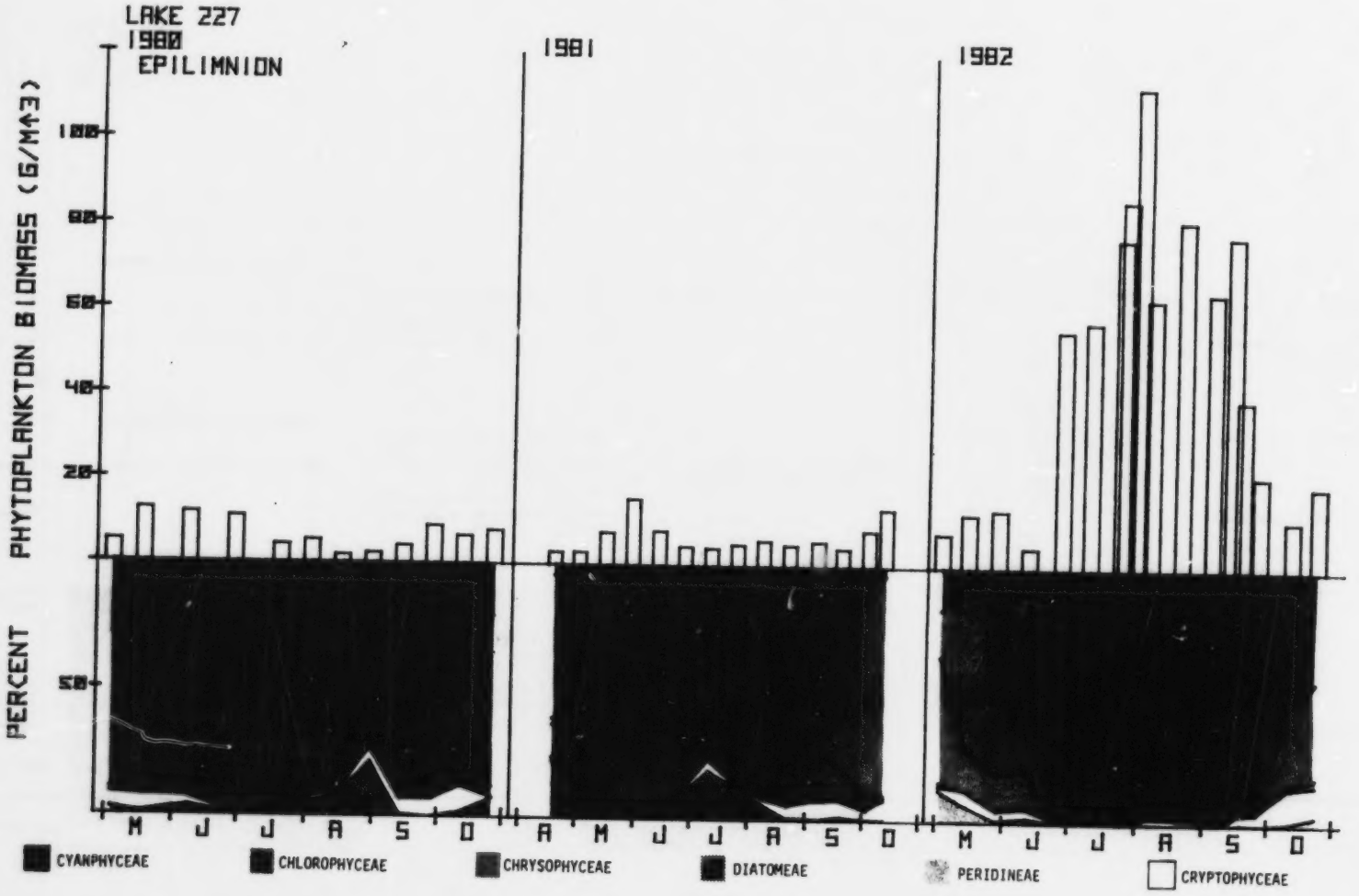

Fig. 1. Average phytoplankton volume in the epilimnion of Lake 227 in 1980-1982, and accumulative percent composition.

Table 2. Lake 227

Common Species (5%)

Strata/Year	Date	Cyanophyceae	Chlorophyceae	Chrysophyceae	Cryptophyceae	Peridineae
Meta 1980	May-Aug	Oscillatoria Redekei Van Goor	Scenedesmus brevispina Chodat Chlorogonium maximum Skuja Chlamydomonas spp. Dictyosphaerium simplex Skuja Oocystis submarina var lacustris Skuja	Dinobryon sertularia Ehren.	Cryptomonas erosa Ehren. C. obovata Skuja	
	Jun-Aug	Anabaena LeVanderi Lemm.		Salpingoeca frequentissima Lemm.		
	Jul-Aug	Aphanizomenon gracile Lemm.	Spondylosium planum W. & G.S. West			Gymnodinium sp.
Meta 1981	May-Aug		Scenedesmus denticulatus Lager. Chlamydomonas spp.			Gymnodinium sp.
	Jun-Aug	Oscillatoria Redekei Van Goor	Scenedesmus brevispina Chodat Spondylosium planum W. & G.S. West Dictyosphaerium simplex Skuja	Dinobryon cylindricum Imhof Chrysochromulina parva Lackey		
		Aphanizomenon gracile Lemm.				Peridinium inconspicuum Lemm.
Meta 1982	May-Jul	Oscillatoria Redekei Van Goor	Scenedesmus denticulatus Lager. S. brevispina Chodat Dictyosphaerium simplex Skuja			Gymnodinium sp.
	Jun-Jul		Chlorogonium maximum Skuja	Dinobryon sertularia Ehren.	Cryptomonas erosa Ehren. C. rostratiformis Skuja	
	Jul	Anabaena planctonica Brunn.				

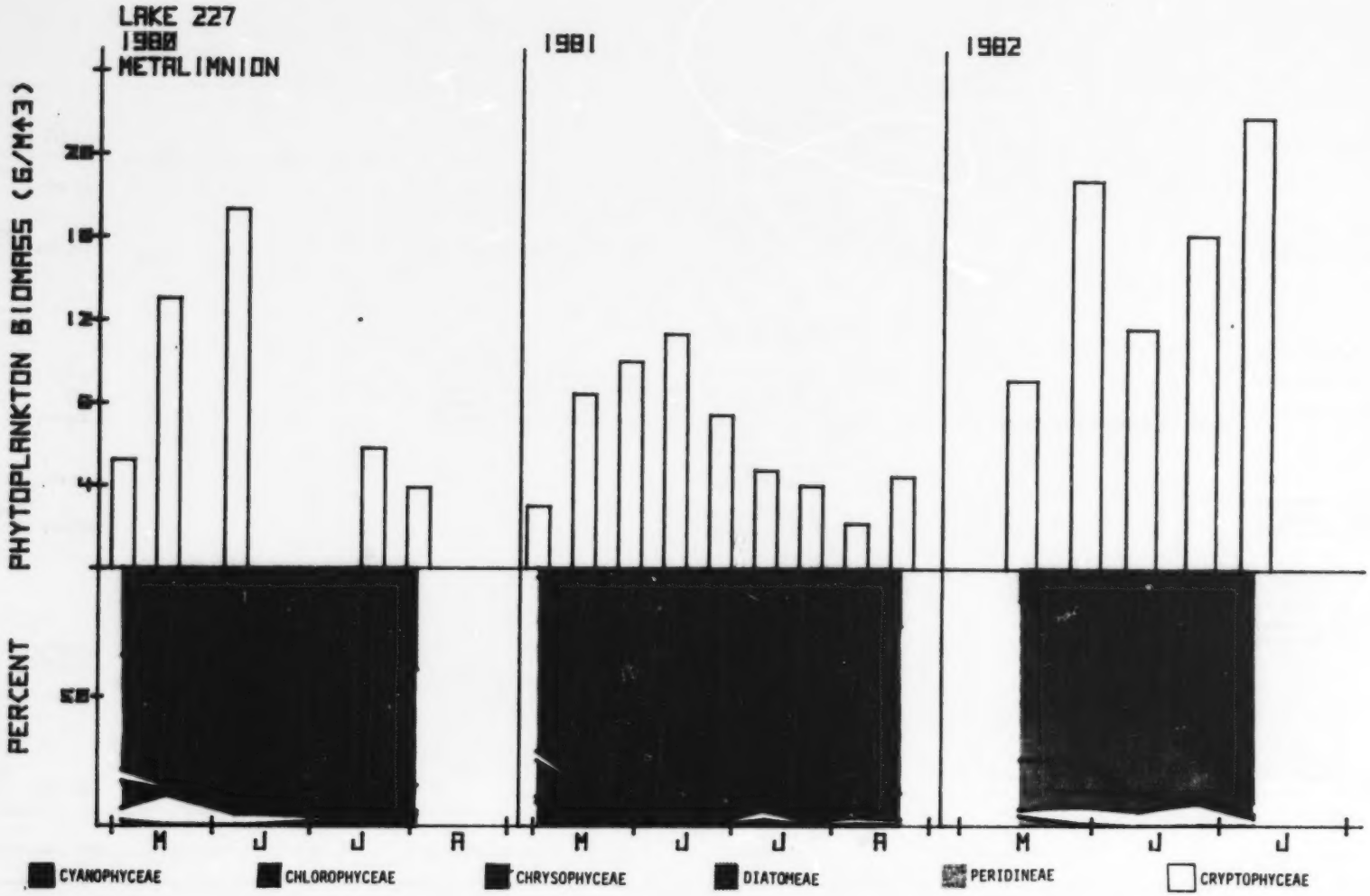

Fig. 2. Average phytoplankton volume in the metalimnion of Lake 227 in 1980-1982, and accumulative percent composition.

Table 3. Lake 226 north

Common Species (5%)

Strata/Year	Date	Cyanophyceae	Chlorophyceae	Chrysophyceae	Diatomeae	Cryptophyceae
Epi 1980	May-Jul			Chrysochromulina parva Lackey Dinobryon sociale Ehren. D. crenulatum W. and G.S. West D. bavaricum Imhof D. sertularia Ehren. Chrysochromulina spp.	Cyclotella comta Kuetz. Synedra acus Kuetz.	Rhodomonas minuta Skuja Cryptomonas erosa Ehren.
	Jun-Oct	Oscillatoria Redekei Van Goor	Dictyosphaerium simplex Skuja Spondylosium planum W & G.S. West	Uroglena americana Calkins	Rhizosolenia eriensis H.L. Smith	
	Jul-Oct Aug-Oct	Anabaena cyclindrica Lemm. A. planctonica Brunn.	Oocystis lacustris Chodat	Chrysochromulina parva Lackey Salpingoeca frequentissima Lemm. Dinobryon bavaricum Imhof D. sertularia Ehren.	Synedra acus Kuetz.	Rhodomonas minuta Skuja Cryptomonas erosa Ehren. C. ovata Ehren.
Epi 1981	Apr-Jun			Chrysolkos Skujai Willen Mallomonas sp.		Cryptomonas erosa Ehren. C. rostratiformis Skuja Rhodomonas minuta Skuja
	May-Jul			Uroglena americana Calkins Dinobryon bavaricum Imhof D. cylindricum Imhof D. sertularia Ehren.		
	Jun-Oct		Monoraphidium setiforme Komar. Oocystis lacustris Chodat Spondylosium planum W. & G.S. West Sphaerozosma granulatum Roy and Bissett	Chrysochromulina parva Lackey Chrysococcus spp. Mallomonas sp. Dinobryon bavaricum Imhof Uroglena americana Calkins Chrysochromulina spp.	Rhizosolenia eriensis H.L Smith Cyclotella glomerata Bach.	R. minuta Skuja Cryptomonas erosa Ehren. C. ovata Ehren.
Epi 1982	May-Oct		Dictyosphaerium simplex Skuja	Chrysochromulina parva Lackey Mallomonas pseudocoronata Pres. Dinobryon bavaricum Imhof Uroglena americana Calkins		Cryptomonas erosa Ehren. C. ovata Ehren. C. reflexa Skuja
	Jun-Oct				Cyclotella glomerata Bach. Rhizosolenia eriensis H.L. Smith Synedra acus Kuetz.	
	Jul-Oct Aug-Oct Oct	Oscillatoria Redekei Van Goor		Chrysochromulina spp. Dinobryon sertularia Ehren.	Tabellaria flocculosa Kuetz.	Gonyostomum semens Diesing

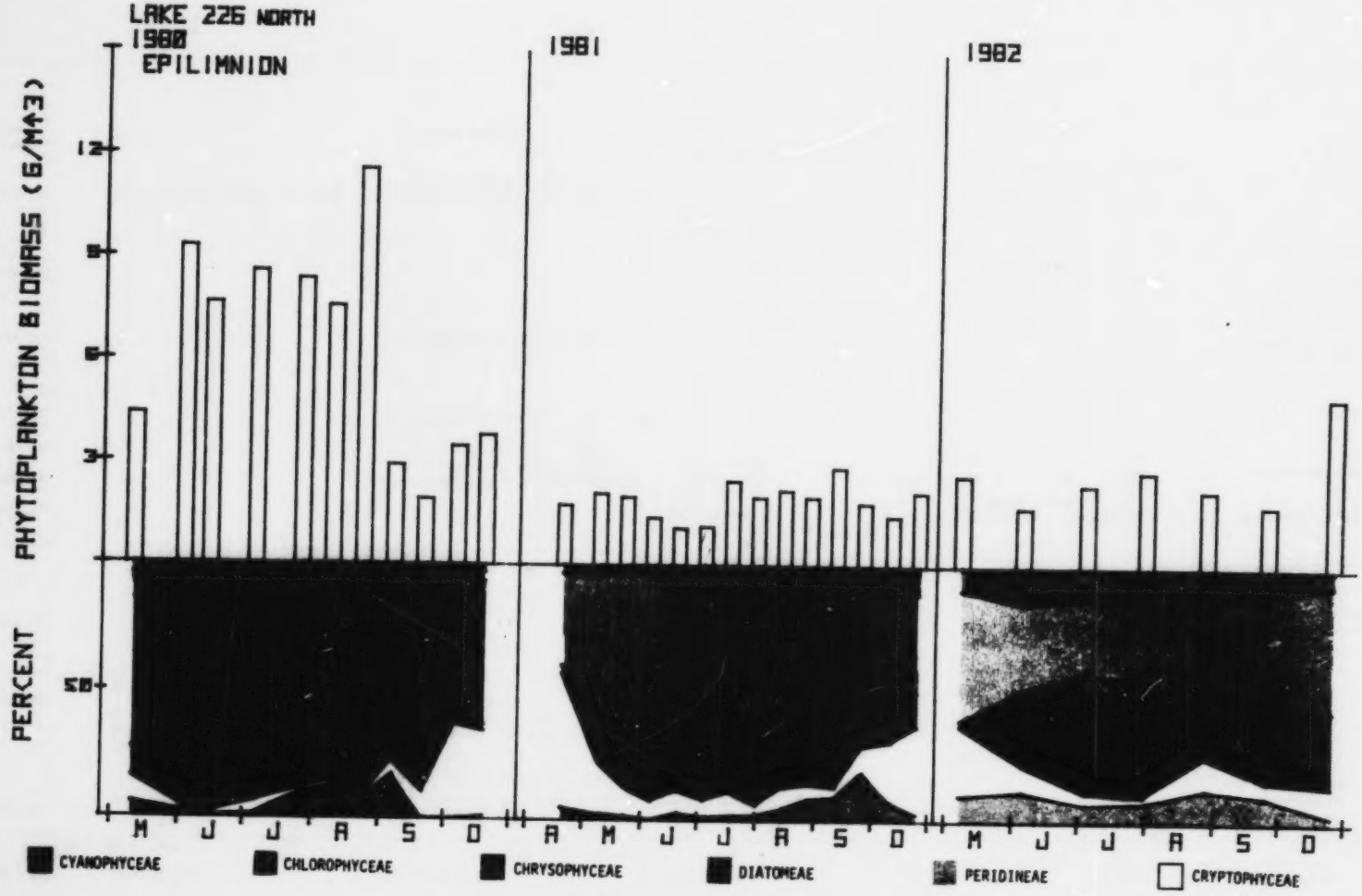

Fig. 3. Average phytoplankton volume in the epilimnion of Lake 226 north in 1980-1982, and accumulative percent composition.

Table 4. Lake 226 north

Strata/Year	Date	Common Species (%)				
		Cyanophyceae	Chlorophyceae	Chrysophyceae	Diatomeae	Cryptophyceae
Meta 1980	May-Sep		Chlamydomonas spp. Dictyosphaerium simplex Skuja Monoraphidium contortum Komar.	Chrysochromulina parva Lackey Dinobryon sertularia Ehren. Uroglena americana Calkins Chrysochromulina spp.	Rhizosolenia eriensis H.L. Smith	Cryptomonas erosa Ehren. C. ovata Ehren. C. obovata Skuja
	Jun-Sep	Oscillatoria Redekie Van Goor Anabaena cylindrica Lemm. A. planctonica Brunn.	Spondylosium planum W. & G.S. West Oocystis submarina var. lacustris Skuja	Synura sphagnicola Korsch.	Synedra acus Kuetz.	
	Jul-Sep					
	Sep	A. LeVanderi Lemm.				
Meta 1981	May-Sep			Chrysococcus spp. Dinobryon bavaricum Imhof D. divergens Imhof Chrysochromulina parva Lackey Dinobryon sociale Ehren. D. sertularia Ehren. Uroglena americana Calkins Mallomonas sp.	Synedra acus Kuetz.	Cryptomonas erosa Ehren. C. rostratiformis Skuja
	Jun-Sep				Cyclotella glomerata Bach. C. comta Kuetz.	
	Aug-Sep		Monoraphidium setiforme Komar. Dictyosphaerium simplex Skuja Gloeococcus Schroeteri Lemm. Oocystis lacustris Chodat Spondylosium planum W. & G.S. West			Rhodomonas minuta Skuja
	Sep					Cryptomonas ovata Ehren.
Meta 1982	May-Sep		Dictyosphaerium simplex Skuja	Chrysochromulina parva Lackey Chrysococcus spp. Mallomonas pseudocoronata Pres. Dinobryon Borgie Lemm. Kephyrion sp. Dinobryon sertularia Ehren. Urgolena americana Calkins Salpingoeca frequentissima Lemm. Chrysochromulina spp.		Cryptomonas erosa Ehren. C. ovata Ehren. C. obovata Skuja C. reflexa Skuja C. rostratiformis Skuja
	Jun-Sep				Cyclotella glomerata Bach. C. comta Kuetz.	
	Jul-Sep	Oscillatoria Redekei Van Goor	Spondylosium planum W. and G.S.West Monoraphidium setiforme Komar.		Rhizosolenia eriensis H.L. Smith Synedra acus Kuetz. Tabellaria flocculosa Kuetz.	Katablepharis ovalis Skuja
	Aug-Sep					
	Sep		Chlamydomonas sp.	Synura sphagnicola Korsch.		

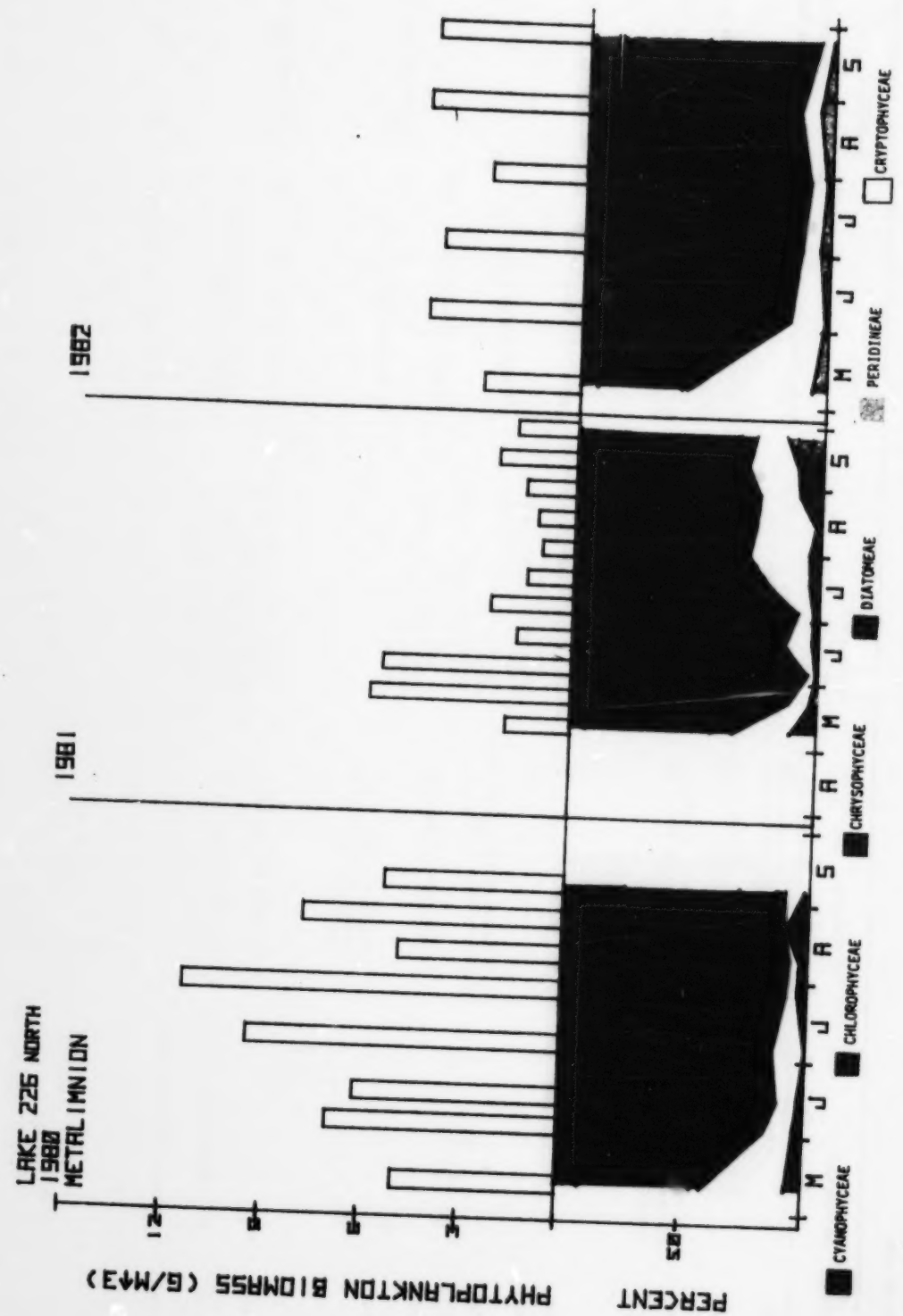

Fig. 4. Average phytoplankton volume in the metalimnion of Lake 226 north in 1980-1982, and accumulative percent composition.

Table 5. Lake 226 south

Common Species (%)

Strata/Year	Date	Cyanophyceae	Chlorophyceae	Chrysophyceae	Diatomeae	Cryptophyceae
Epi 1980	May-Jul		Dictyosphaerium simplex Skuja Monoraphidium contortum Komar.	Chrysochromulina parva Lackey Dinobryon bavaricum Imhof Uroglena americana Calkins	Rhizosolenia eriensis H.L. Smith	Cryptomonas erosa Ehren. C. ovata Skuja
	Jun-Jul		Spondylosium planum W. & G.S. West Chlamydomonas spp.	Dinobryon sertularia Ehren. Chrysochromulina spp.	Cyclotella glomerata Bach. C. comta Kuetz. Synedra acus Kuetz.	Rhodomonas minuta Skuja
	Jul-Oct	Oscillatoria Redekei Van Goor O. tenuatica Lemm.	Oocystis lacustris Chodat Spondylosium planum W. & G.S. West	Chrysochromulina parva Lackey	Cyclotella comta Kuetz.	
	Aug-Oct Sep-Oct	Anabaena LeVanderi Lemm.		Synura sphagnicola Korsch.	Cyclotella glomerata Bach. Rhizosolenia eriensis H.L. Smith	Cryptomonas erosa Ehren.
Epi 1981	Apr-Jul			Chrysolkos Skujai Willen		Cryptomonas erosa Ehren.
	May-Jul			Uroglena americana Calkins Dinobryon bavaricum Imhof Chrysochromulina parva Lackey Dinobryon sociale Ehren.	Cyclotella glomerata Bach.	
	Jun-Aug		Scenedesmus denticulatus Lager.	Chrysococcus spp.	Cyclotella comta Kuetz.	
	Jul-Oct		S. brevispina Chodat	Kephyrion sp. Chrysochromulina parva Lackey Dinobryon cremulatum W. & G.S. West		
	Aug-Oct		Dictyosphaerium simplex Skuja	D. bavaricum Imhof Uroglena americana Calkins Chrysochromulina spp.	Rhizosolenia eriensis H.L. Smith	
	Sep-Oct Oct		Chlamydomonas spp. Sphaerozosma granulatum Roy and Bissett	Chrysococcus sp.	Cyclotella glomerata Bach.	Cryptomonas erosa Ehren.
Epi 1982	May-Oct		Tetraedron minimum Hans.	Chrysochromulina parva Lackey Dinobryon sertularia Ehren. Chrysochromulina spp.	Rhizosolenia eriensis H.L. Smith	Cryptomonas erosa Ehren. C. reflexa Skuja
	Jun-Oct	Oscillatoria Redekei Van Goor	Chlamydomonas spp.	Dinobryon bavaricum Imhof Uroglena americana Calkins	Cyclotella glomerata Bach. Synedra acus Kuetz.	
	Aug-Sep	Anabaena planctonica Brunn.		Chrysosphaerella longispina Laut.		

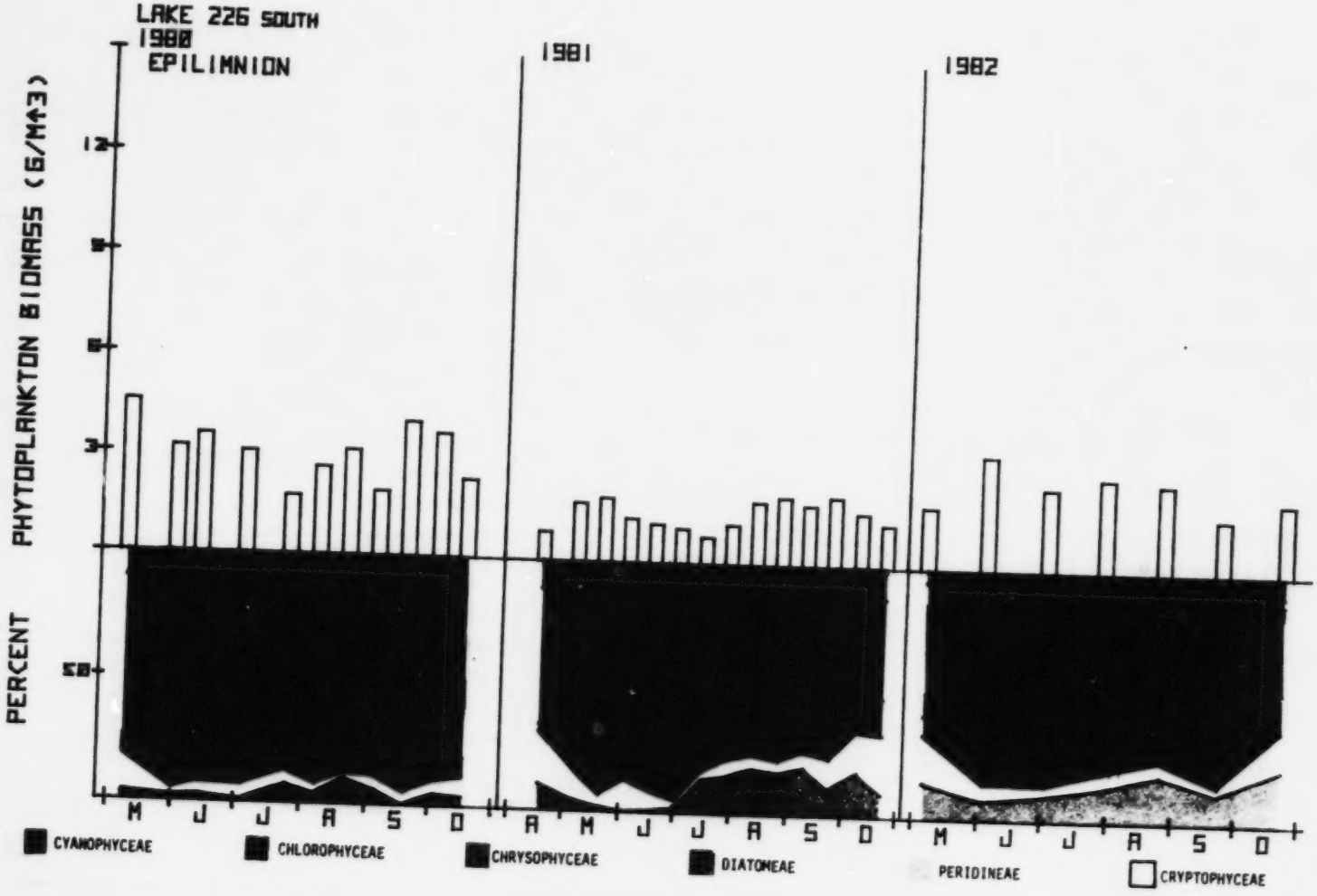

Fig. 5. Average phytoplankton volume in the epilimnion of Lake 226 south in 1980-1982, and accumulative percent composition

Table 6. Lake 226 south

Common Species (5%)

Strata/Year	Date	Cyanophyceae	Chlorophyceae	Chrysophyceae	Diatomeae	Cryptomonas
Meta 1980	May-Sep		Dictyosphaerium simplex Skuja Botryococcus Braunii Kuetz.	Uroglena americana Calkins Dinobryon sociale Ehren. Chrysochromulina spp. C. parva Lackey		
	Jun-Sep		Spondylosium planum W. & G.S. West	Synura sphagnicola Korsch. Dinobryon crenulatum W. & G.S. West D. bavaricum Imhof D. sertularia Ehren.	Cyclotella comta Kuetz. C. glomerata Bach. Synedra acus Kuetz. Rhizosolenia eriensis H.L. Smith	
	Jul-Sep	Oscillatoria Redekei Van Goor O. limnetica Lemm. Anabaena cylindrica Lemm.	Oocystis lacustris Chodat			Katablepharis ovalis Skuja Cryptomonas erosa Ehren.
Meta 1981	May-Sep		Chlamydomonas spp.	Dinobryon bavaricum Imhof D. sertularia Ehren. Chrysochromulina parva Lackey Uroglena americana Calkins	Cyclotella glomerata Bach.	Cryptomonas erosa Ehren.
	Jun-Sep Jul-Sep		Scenedesmus denticulatus Lager.	Chrysococcus spp.		C. obovata Skuja
	Jul-Aug	Chroococcus limneticus Lemm. Oscillatoria Redekei Van Goor	Dictyosphaerium simplex Skuja			
	Aug-Sep Aug Sept		Spondylosium planum W. & G.S. West	Chrysocphaerella longispina Laut.	C. comta Kuetz. Rhizosolenia eriensis H.L.Smith	C. ovata Ehren.
Meta 1982	May-Sep		Chlamydomonas spp.	Chrysochromulina spp. C. parva Lackey Chrysococcus sp. Dinobryon sertularia Ehren.		Cryptomonas erosa Ehren.
	Jun-Sep		Dictyosphaerium simplex Skuja	Mallomonas pseudocoronata Pres. Uroglena americana Calkins Chrysosphaerella longispina Laut. Dinobryon bavaricum Imhof Salpingoeca frequentissima Lemm.		C. ovata Ehren. Katablepharis ovalis Skuja
	Jul-Sep	Oscillatoria Redekei Van Goor				
	Aug-Sep				Rhizosolenia eriensis H.L. Smith Tabellaria flocculosa Kuetz.	

Note: Common Peridinean - Amphidinium sp. (1981)

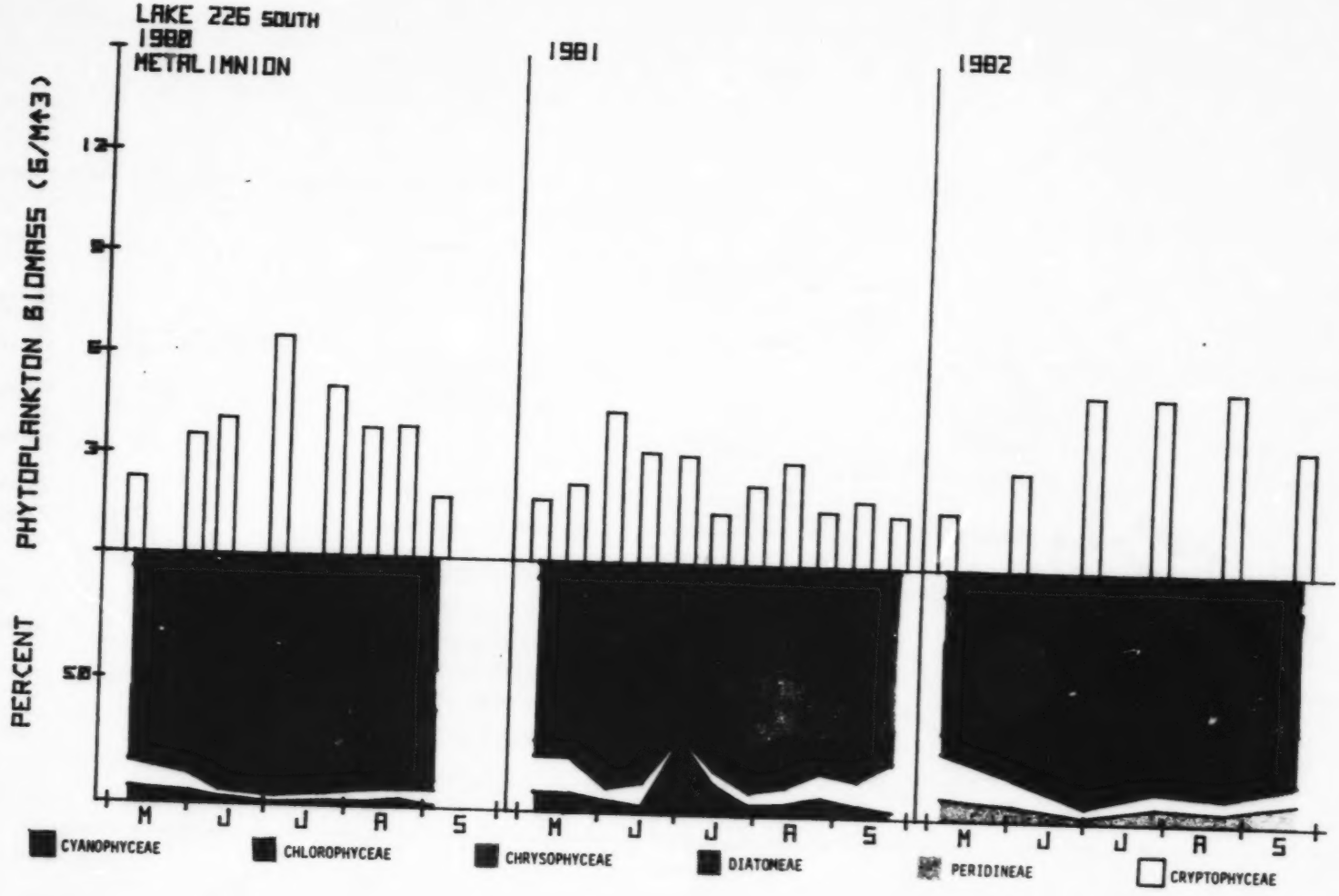

Fig. 6. Average phytoplankton volume in the metalimnion of Lake 226 south in 1980-1982, and accumulative percent composition.

Table 7. Lake 302 north

Common Species (5%)

Strata/Year	Date	Cyanophyceae	Chlorophyceae	Chrysophyceae	Cryptophyceae	Peridineae
Epi 1980	Jun-Aug		Oocystis submarina var. lacustris Skuja	Uroglena americana Calkins	Rhodomonas minuta Skuja	
				Stichogloea spp.		
	Jul-Aug	Synechococcus sp.	Gloeococcus Schroeteri Lemm.	Dinobryon bavaricum Imhof	Cryptomonas erosa Ehren.	Gymnodinium sp.
			Oocystis submarina var. lacustris Skuja	Chrysococcus sp.		Ceratium hirundinella Schrank
	Sep-Oct			Dinobryon bavaricum Imhof		
				Chrysococcus sp.	C. erosa Ehren.	
	Oct			Dinobryon sertularia Ehren.		Gymnodinium sp.
				Uroglena americana Calkins		
Epi 1981	Apr-Jun		Dictyosphaerium simplex Skuja	Chrysococcus sp.	Cryptomonas erosa Ehren.	
				Chrysochromulina parva Lackey		
	Apr-Oct		Arthrodesmus incus Hasslow	Dinobryon bavaricum Ehren.		
				D. sertularia Ehren.	C. rostratiformis Skuja	
	May-Oct			Chrysolkos planctonicus Mach.	C. ovata Ehren.	Peridinium Willei Huit.-Kaas
				Dinobryon crenulatum W. & G.S. West		
				Uroglena americana Calkins	Katablepharis ovalis Skuja	Gymnodinium sp.
	Jun-Oct		Oocystis submarina var. lacustris Skuja		Rhodomonas minuta Skuja	
			Dictyosphaerium simplex Skuja			
	Jul-Oct	Synechococcus sp.	Gloeococcus Schroeteri Lemm.		Cryptomonas erosa Ehren.	Ceratium hirundinella Schrank
		Chroococcus limneticus Lemm.		Uroglena americana Calkins		
	Aug-Oct			Chrysochromulina parva Lackey		
	Sep-Oct			Chrysosphaerella longispina Laut.		Gymnodinium sp.
				Chrysococcus sp.		
				Salpingoeca frequentissima Lemm.		
				Dinobryon sertularia Ehren.		
	Oct		Chlamydomonas spp.			

Note: Common Diatomeae - Asterionella Gracillima Hassale (1981, Apr-Jun)

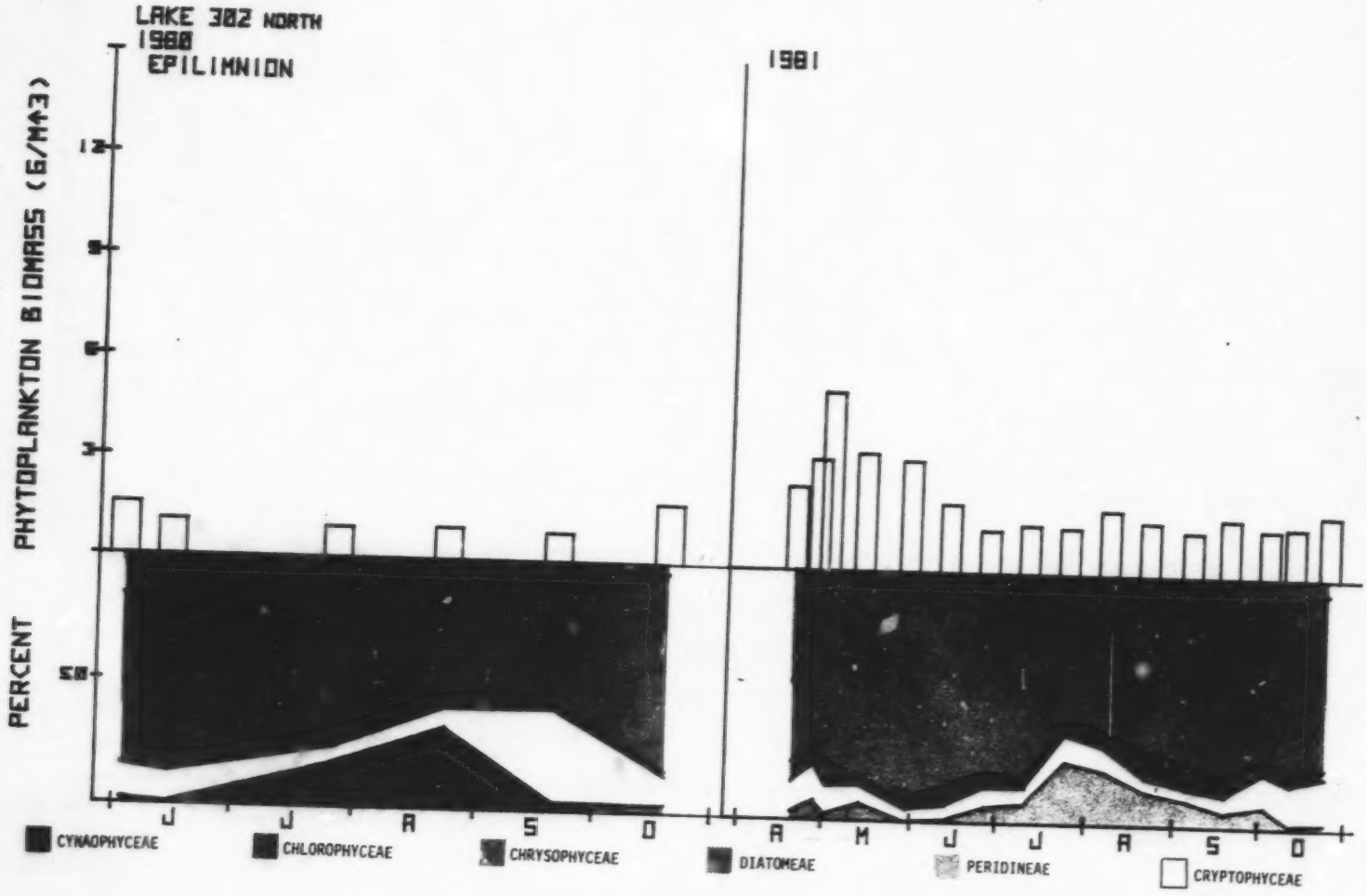

Fig. 7. Average phytoplankton volume in the epilimnion of Lake 302 north in 1980 & 1981, and accumulative percent composition.

Table 8. Lake 302 north

Common Species (5%)

Strata/Year	Date	Cyanophyceae	Chlorophyceae	Chrysophyceae	Cryptophyceae	Peridineae
Meta 1980	Jun-Aug		Oocystis submarina var. lacustris Skuja	Dinobryon bavaricum Imhof	Rhodomonas minuta Skuja	
			Chlamydomonas spp.	Uroglena americana Calkins	Cryptomonas erosa Ehren.	
			Botryococcus Braunii Kuetz.	Stichogloea sp.		
	Jul-Aug		Gloeococcus Schroeteri Lemm.	Mallomonas caudata Iwan.		
				Chrysosphaerella longispina Laut.		Ceratium hiruninella Schrank
	Aug	Synechococcus sp.				Gymnodinium sp.
Meta 1981	May		Arthrodesums incus Hasslow	Chrysococcus sp.	Cryptomonas erosa Ehren.	Peridinium Willei Huit.-Kaas
				Chromulina sp.	C. rostratiformis Skuja	Gymnodinium sp.
				Dinobryon bavaricum Imhof	Rhodomonas minuta Skuja	
				D. crenulatum W. and G.S. West		
			Dictyosphaerium simplex Skuja	Chrysochromulina spp.		
				Uroglena americana Calkins		
				Chrysochromulina parva Lackey		
	July	Anabaena sp.		Mallomonas hamata		
	Aug					Ceratium hirundinella Schrank
				Dinobryon sertularia Ehren.		
	Sep		Botryococcus Braunii Kuetz.	Chrysosphaerella longispina Laut.		
			Chlamydomonas spp.	Salpingoeca frequentissima Lemm.		
				Mallomonas caudata Iwan.		
				M. sp.	Cryptomonas ovata Ehren.	

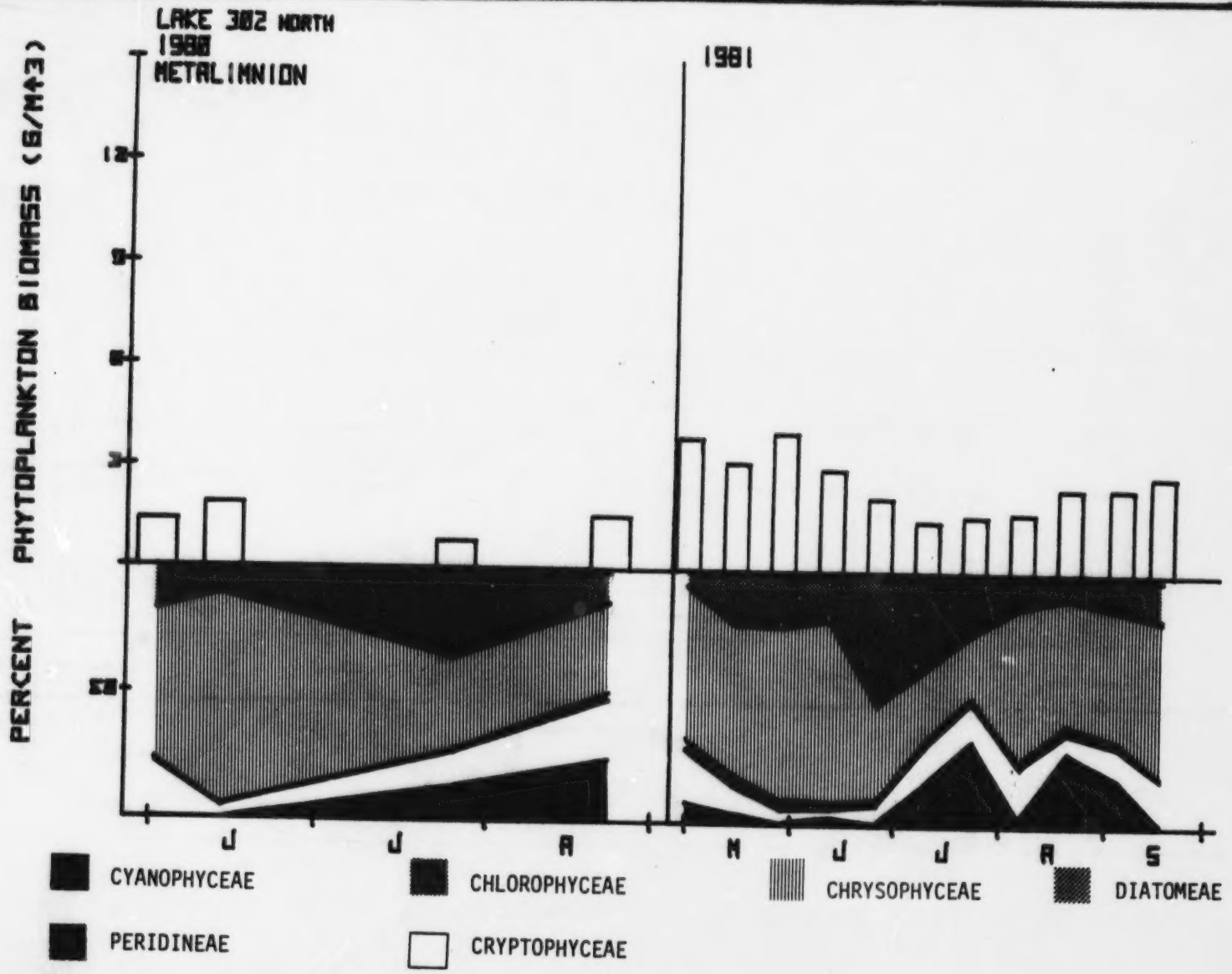

Fig. 8. Average phytoplankton volume in the metalimnion of Lake 302 north in 1980 and 1981, and accumulative percent composition.

Table 9. Lake 302 north

Common Species (%)

Strata/Year	Date	Chlorophyceae	Chrysophyceae	Diatomeae	Cryptophyceae	Peridineae
Hypo 1980	Jun	Oocystis lacustris Chodat Dictyosphaerium simplex Skuja Scenedesumus denticulatus Lager. Monorophidium setiforme Komar.	Dinobryon bavaricum Imhof Mallomonas sp. Kephyrion spirale Conrad Chrysococcus sp. Uroglena americana Calkins	Asterionella formosa Hassall	Rhodomonas minuta Skuja Cryptomonas erosa Ehren. C. rostratiformis Skuja	
Hypo 1981	May-Jun	Chlamydomonas spp. Arthrodesmus incus Hasslow	Chrysococcus sp. Chromulina sp Dinobryon bavaricum Imhof Uroglena americana Calkins Mallomonas hamata	Rhizosolenia eriensis H.L. Smith	Cryptomonas erosa Ehren.	Peridinium sp.
		Dictyosphaerium simplex Skuja			C. rostratiformis Skuja Katablepharis ovalis Skuja	Peridinium Willie Huit.-Kass
	Jun			Tabellaria fenestrata Kuetz.		

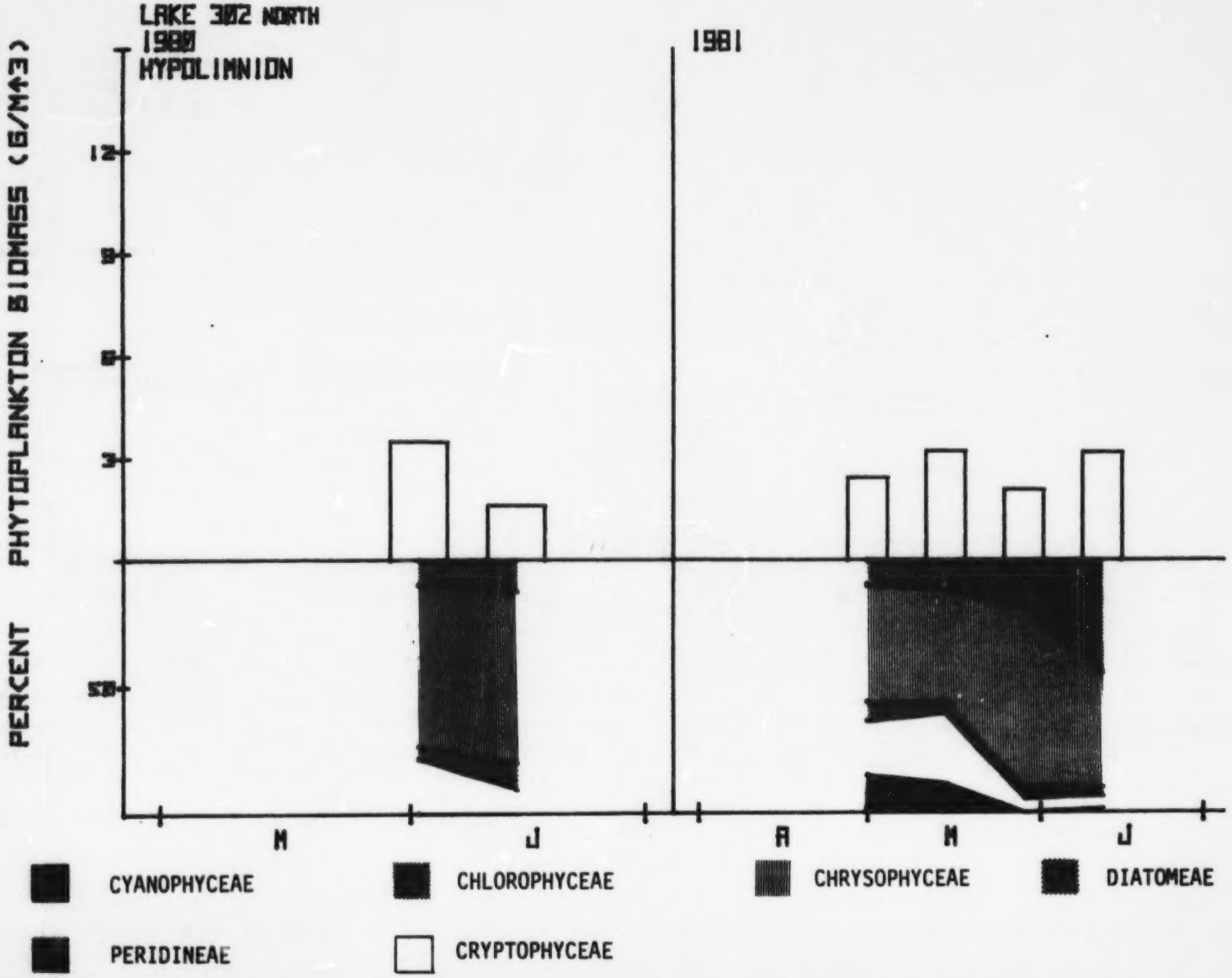

Fig. 9. Average phytoplankton volume in the hypolimnion of Lake 302 north in 1980 and 1981, and accumulative percent composition.

Table 10. Lake 302 south

Common Species (%)

Strata/Year	Date	Cyanophyceae	Chlorophyceae	Chrysophyceae	Cryptophyceae	Peridineae
Epi 1980	Jun-Oct		Botryococcus Braunii Kuetz.	Chrysococcus sp. Chromulina sp. Dinobryon bavaricum Imhof		
	Jul-Sep	Synechococcus sp.	Oocystis lacustris Chodat		Cryptomonas erosa Ehren.	Gymnodinium sp. Ceratium hirundinella Schrank
	Aug-Oct	Chroococcus limneticus Lemm.	Quadrigula closterioides Printz			
	Sep-Oct			D. sertularia Ehren.	Rhodomonas minuta Skuja	
	Oct			Urgolena americana Calkins	Katablepharis ovalis Skuja	
Epi 1981			Dictyosphaerium simplex Skuja	Chrysococcus sp. Dinobryon bavaricum Imhof	Cryptomonas erosa Ehren.	
			Arthrodesmus incus Hasslow	Chrysochromulina spp. Uroglena americana Calkins		
	May-Oct		Oocystis lacustris Chodat	Dinobryon sertularia Ehren.	C. rostratiformis Skuja	
	Jun-Oct			Chrysochromulina parva Lackey	Rhodomonas minuta Skuja	Gymnodinium sp.
	Jul-Oct	Chroococcus limneticus Lemm. Synechococcus sp.	Monoraphidium setiforme Komark. Spondylosium planum W. and G.S. West			Ceratium hirundinella Schrank Peridinium wisconsinense Eddy
	Aug-Oct				Katablepharis ovalis Skuja	
	Sep-Oct		Botryococcus Braunii Kuetz.	Dinobryon sertularia Ehren.		
	Oct				Cryptomonas ovata Ehren.	

Note: Common Diatomeae - Synedra acus (1981, Jun-Oct)

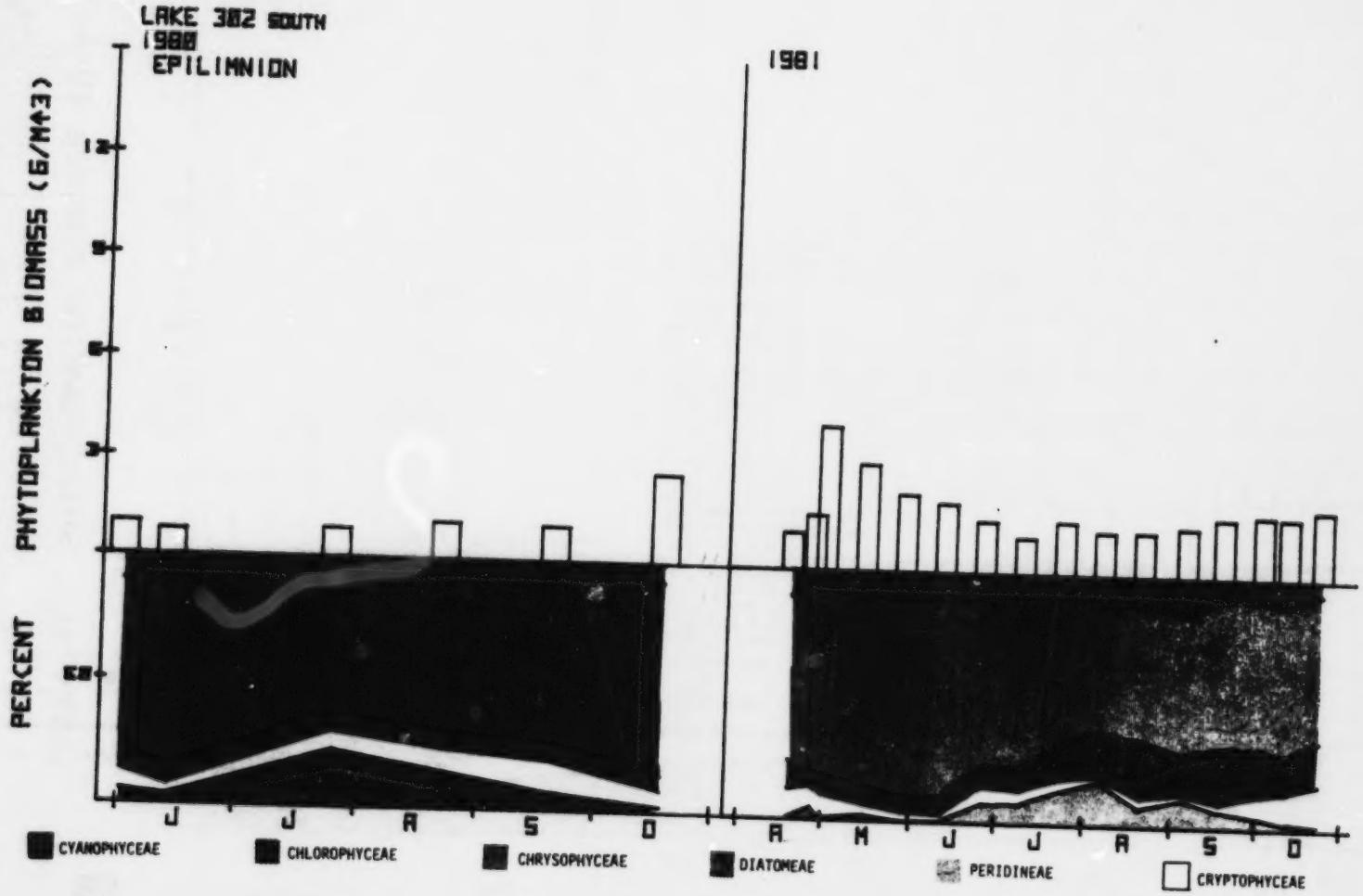

Fig. 10. Average phytoplankton volume in the epilimnion of Lake 302 south in 1980 & 1981, and accumulative percent composition.

Table 11. Lake 302 south

Common Species (%)

Strata/Year	Date	Cyanophyceae	Chlorophyceae	Chrysophyceae	Cryptophyceae	Peridineae
Meta 1980	Jun-Jul		Botryococcus Braunii Kuetz. Oocystis lacustris Chodat O. submarina var. lacustris Skuja	Dinobryon bavaricum Imhof D. bavaricum var. Vanhoeffenii Kreig. Urgolena americana Calkins Stichogloea spp. Chrysosphaerella longispina Laut.		
	Jul-Aug	Synechococcus sp.	Chlamydomonas spp. Gloeocystis planctonica Lemm.	Mallomonas hamata Chrysococcus sp. Urgolena americana Calkins	Cryptomonas erosa Ehren.	Gymnodinium sp.
	Aug			Salpingoeca frequentissima Lemm. Chromulina sp.	C. ovata Ehren.	Ceratium hirundinella Schrank
Meta 1981	May-Sep		Monoraphidium setiforme Komar.	Chrysococcus sp. Dinobryon bavaricum Imhof Uroglena americana Calkins	Rhodomonas minuta Skuja	Gymnodinium sp.
	Jun-Sep.		Dictyosphaerium simplex Skuja Arthrodesmus incus Hasslow	Chrysochromulina parva Lackey Dinobryon sertularia Ehren. Mallomonas hamata	Katablepharis ovalis Skuja	
	Jul-Sep		Botryococcus Braunii Kuetz. Chlamydomonas spp.	Chromulina sp.	Cryptomonas erosa Ehren.	
	Sep			Synura sphagnicola Korsch. Mallomonas pseudocoronata Pres. Chrysochromulina spp.	C. ovata	

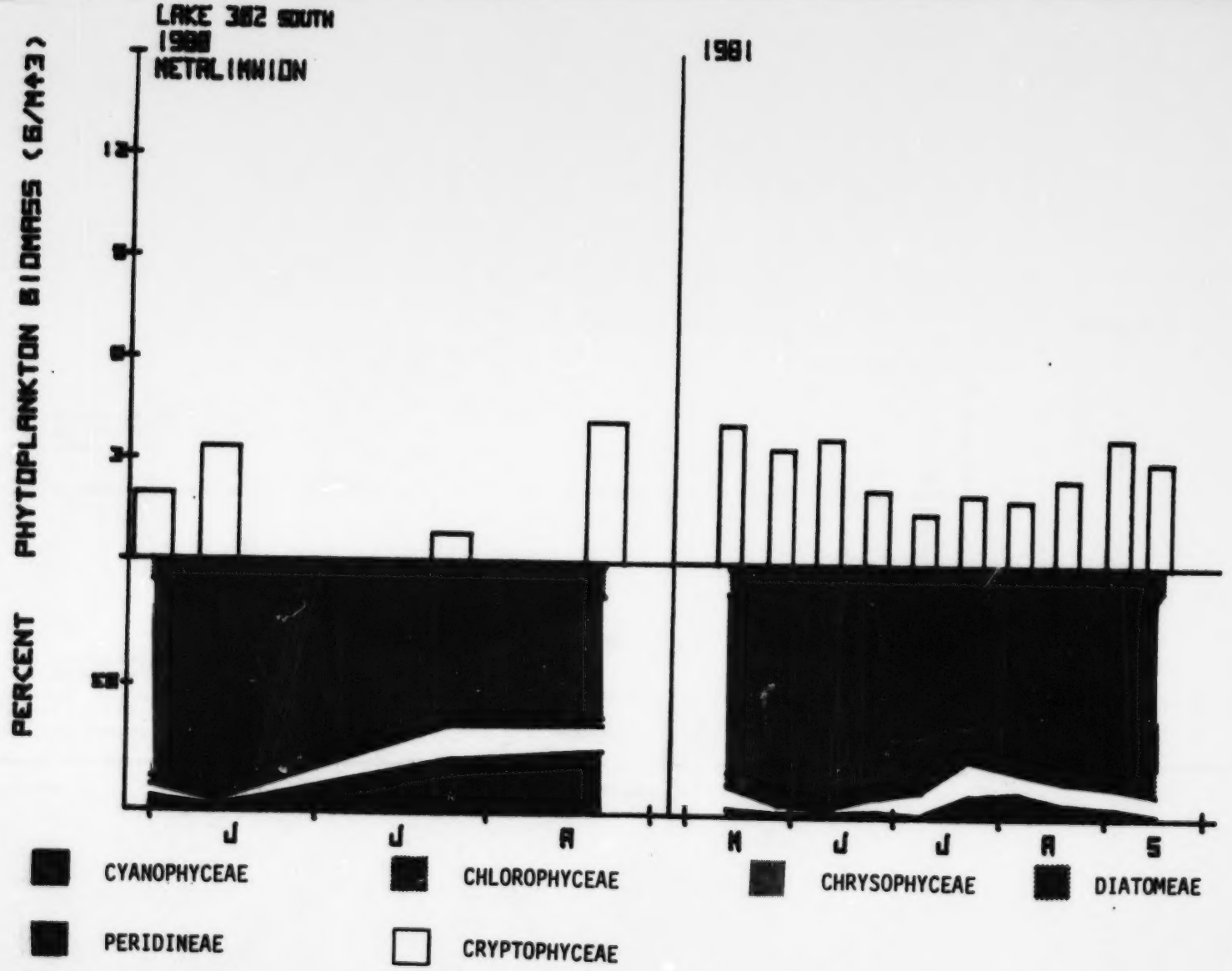

Fig. 11. Average phytoplankton volume in the metalimnion of Lake 302 south in 1980 and 1981, and accumulative percent composition.

Table 12. Lake 302 south

Strata/Year	Date	Common Species (%) Chlorophyceae	Chrysophyceae	Diatomeae	Cryptophyceae	Peridineae
Hypo 1980	Jun	Dictyosphaerium simplex Skuja Botryococcus Braunii Kuetz.	Chrysococcus sp. Chromulina sp. Dinobryon bavaricum Imhof D. crenulatum W. and G.S. West D. bavaricum var. Vanhoeffenii Kreig. Uroglena americana Calkins Chrysosphaerella longispina Laut. Mallomonas pseudocoronata Pres.		Cryptomonas erosa Ehren. C. ovata Ehren. C. rostratiformis Skuja	
Hypo 1981	May-Jun	Dictyosphaerium simplex Skuja Oocystis lacustris Chodat Monoraphidium setiforme Komar. Arthrodesmus incus Hasslow	Chrysococcus spp. Chromulina sp. Kephyrion boreale Skuja Dinobryon bavaricum Imhof Ochromonas sp. Kephyrion sp. Mallomonas akrokomas Ruttner Dinobryon sertularia Ehren. D. crenulatum W. & G.S. West D. divergens Imhof Uroglena americana Calkins Mallomonas sp.	Rhizosolenia eriensis H.L. Smith	Cryptomonas erosa Ehren. Katablepharis ovalis Skuja	
	Jun			Tabellaria fenestrata Kuetz.		Gymnodinium sp.

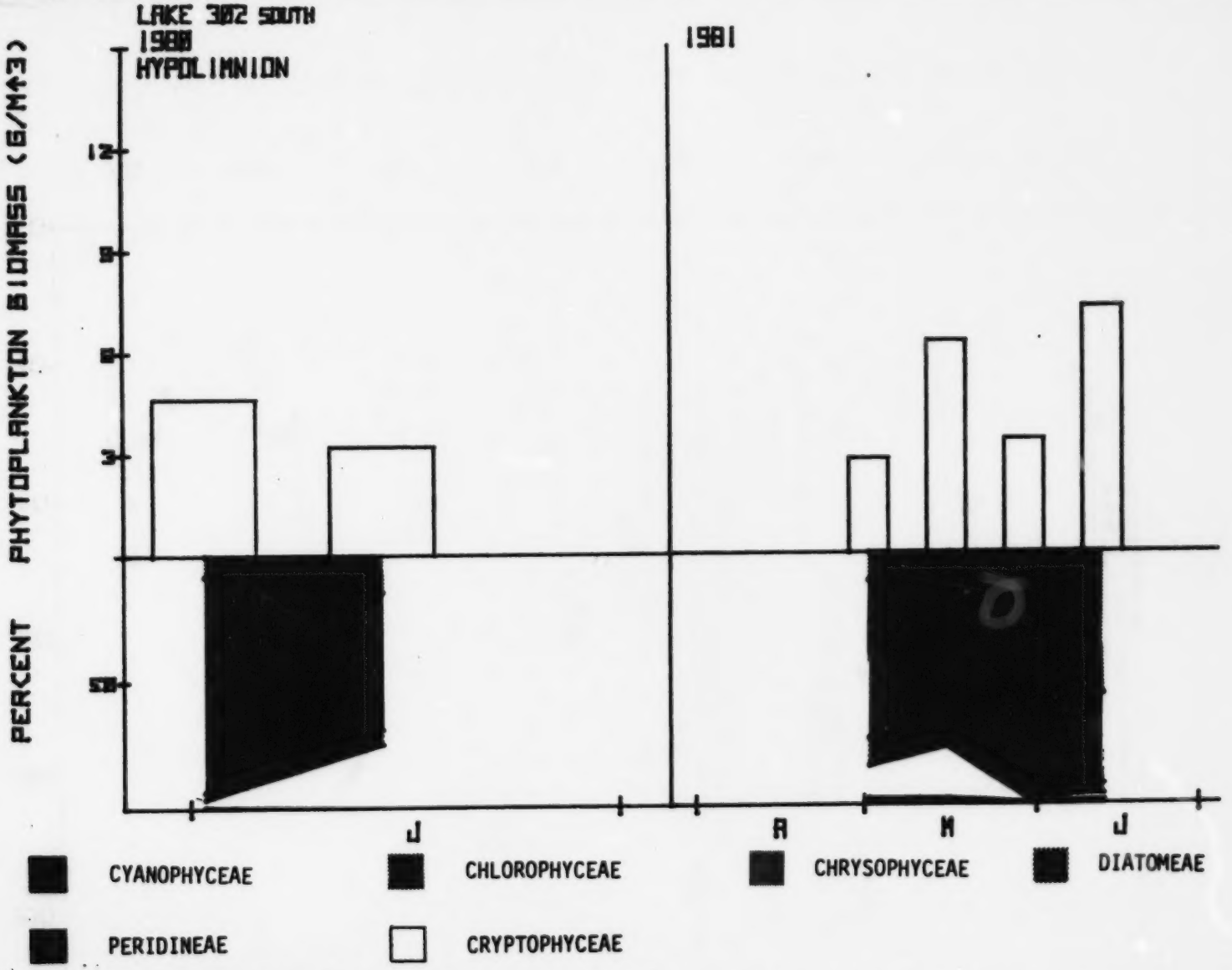

Fig. 12. Average phytoplankton volume in the hypolimnion of Lake 302 south in 1980 and 1981, and accumulative percent composition.

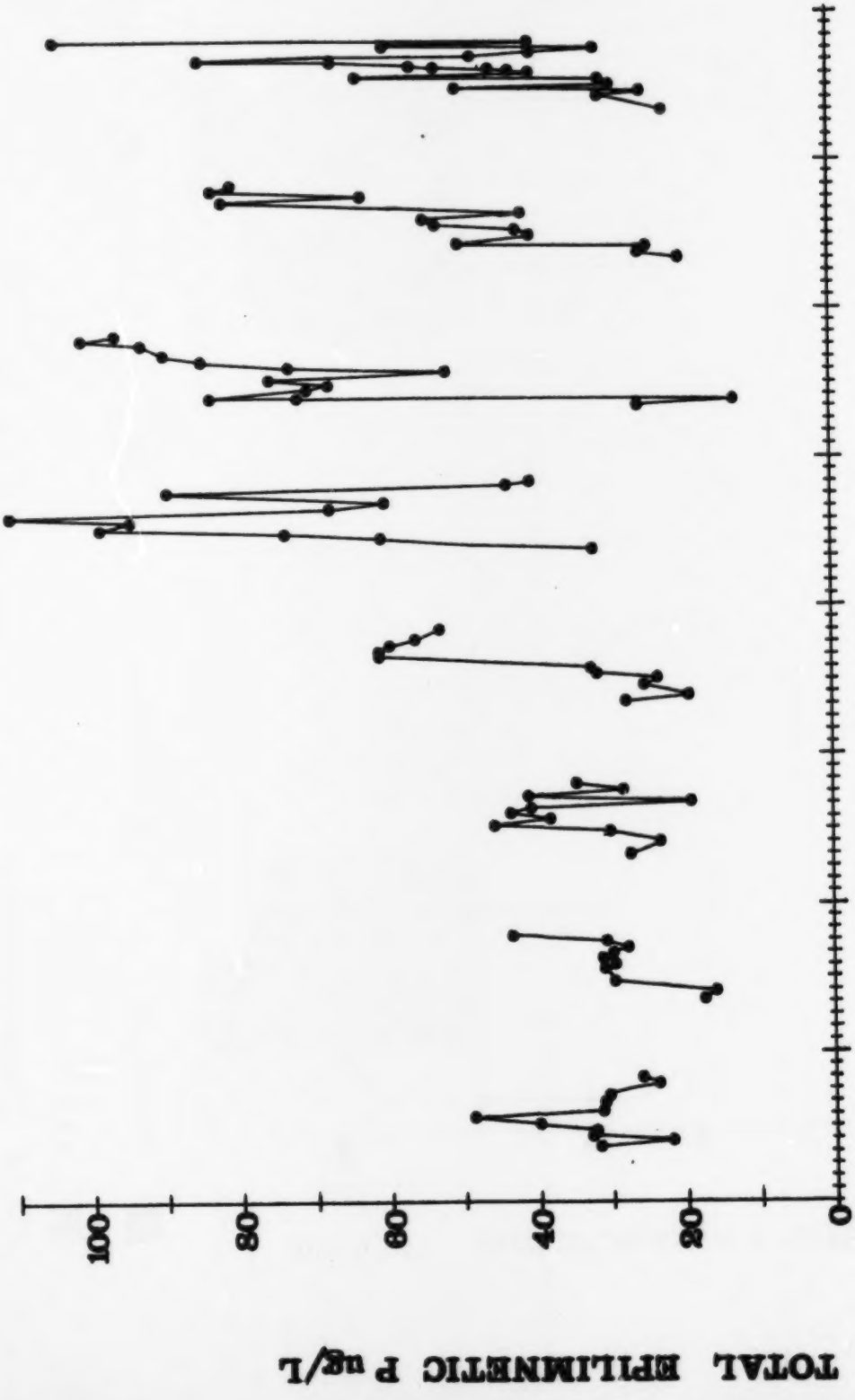

Fig. 13. Total epilimnetic phosphorus (µg/L) in Lake 227 from 1975 to 1982.

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